C66-2990

[redacted]

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
Exhibit E, Para. 7.3	023	LEM	NAS 9-1100	1-14-63

TYPE II

Primary 760

GROUP-4
Downgraded at 3 year intervals;
declassified after 12 years

REPORT

NO. LPR-550-10 DATE: 11-1-1965

QUARTERLY RELIABILITY STATUS REPORT U

CODE 26512

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REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

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GRUMMAN AIRCRAFT ENGINEERING CORPORATION

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ABSTRACT

This Quarterly Reliability Status Report is submitted in fulfillment of the requirements of Paragraph 7.3 of Reference (a), and is the tenth in a series of reports to be submitted as part of the Reliability Plan.

1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

This report covers the period from 15 June to 15 September 1965. During this report period, major effort has been expended in:

a. Preparation and completion of major subsystem Reliability Models.

b. Participation in a summary meeting with the Systems Reliability Analysis Management Panel on the above mentioned models.

c. Support of the Subsystem design effort by participation in equipment Design Reviews and configuration studies.

d. Preparing updating and completing system level FMEA's on all subsystems.

e. Participation in Certification Test Review with NASA; Implementation of Certification Test Program on all subcontracts and revising all boiler plates to reflect the latest NASA test requirements.

f. Evaluation of Parts Specifications and part approval requests.

The updated reliability estimates based on the Design Reference Mission is shown in the following table:

	Reliability Estimate		Reliability
	This Quarter	Last Quarter	Goal
Mission Success	.856	.866	0.984
Crew Safety	.99642	.99680	0.9995

1.0 INTRODUCTION AND SUMMARY (continued)

1.1 Introduction (continued)

The differences in mission success can be attributed to (a) a change in latest MIT failure rates in the Navigation and Guidance system, (b) changes in the Ascent propulsion system and Ascent Engine Math model, (c) an update of the ECS reliability based on the latest schematics. In addition to the above, differences in crew safety can also be attributed to a more detailed, updated crew safety model for the EPS and ECS.

1.2 Summary

During the week of 30 August, the GE/NASA System Reliability Analysis Management Panel visited GAEC Reliability at which time all the major subsystem reliability models were discussed and reviewed. At that time it was agreed that the models and failure rates presented would constitute a datum for future modeling effort.

In this report period there were some significant subsystem changes such as: In the Descent Propulsion System (a) removal of the secondary regulator in each leg, (b) placing of squib valves downstream of the quad check valves, (c) providing isolation valves for the engine solenoid valves, (d) replacing low propellant level detection with continuous level sensing. In the Ascent Propulsion System, (a) placing of redundant squib valves downstream of quad check valves, (b) providing isolation valves for the engine solenoids valves. In the Instrumentation subsystem, a probable change will be eliminating redundancy of the Timing Equipment Assembly power supply.

1.0 INTRODUCTION AND SUMMARY (continued)

1.2 Summary (continued)

During the period from 19 July to 23 July the test program was reviewed in preparation for determining a base line from which a Certification Test Program could be implemented. One major output from this review was the NASA direction that the qual test program be modified to conform to "Qualification Test Program Guidelines" ASPO-R&QA-11.

2.0 PROGRAM MANAGEMENT

During this quarter there has been a changeover from schedule 37 to schedule III revision 1. All reliability milestones are presently consistent with the approved schedule.

3.0 SYSTEM ANALYSIS

This section describes the LEM system status as of September 15, 1965 and the system level studies and tasks performed during this reporting period.

3.1 Systems (Contracted End Item) Milestone Charts

No effort has been expended on this item during this report period.

3.2 Reliability Mission Profile

As in the past reporting period the DRM presented in LPR-550-8, Section 3.2.1 was utilized in all reliability studies.

3.2.2 LEM Development Missions

The equipment operating profiles to support the LEM-1, 206A, mission analysis were completed. Reliability considerations including a systems failure effects analysis was prepared and included in the LEM-1 Mission Capability Report, LED-540-41.

3.3 Reliability Apportionments and Estimates

Mission Success and Crew Safety apportionments and estimates for each of the LEM subsystems are presented in Tables 3.3.1 and 3.3.2. The estimates are based on the Design Reference Mission. However, as per MSC directive, prelaunch time (10 hours) is no longer considered in the reliability estimates. The apportionments that are shown in the tables are based on the "Mission Profile for Reliability Estimates", described in previous reliability quarterly reports. Discussed below are the major changes which have occurred in the reliability estimates for the Navigation and Guidance, Ascent and Descent Propulsion Subsystems, EPS, ECS and Explosive Devices Subsystem and possible future modifications of other major subsystem estimates.

3.3.1 Electrical Power Subsystem

During this report period, the reliability crew safety and mission success estimates reported for the Electrical Power Subsystem have changed. The mission success estimate increased and the crew safety estimate decreased when compared to the data presented for the previous reporting period. During this reporting period a more detailed model was utilized to generate the estimates. LED-550-69 documents the model and support data utilized to generate the current estimates.

3.3.2 Propulsion

Ascent

The reliability estimate for this subsystem has decreased from the previous report. This is due mainly to a change in the Ascent engine math model (incorporation of the propellant leakage failure mode for the 3-way solenoid valves.)

Evaluations were performed to determine the effects on reliability by the addition of solenoid operated shut-off valves to prevent propellant leakage past the engine solenoid valves from earth launch until pre-lunar launch pressurization.

Descent

Revised failure rates for the mechanical components of the Descent engine (Propellant Shut-off Valves, Flow Control Valves, Piping and Ducting, and the injector) have reduced the reliability of this subsystem.

To eliminate the problem of fuel freezing in the supercritical helium system (possible catastrophic failure), incorporation of a method for firing the descent engine 1.3 ± .4 second prior to pressurization has been evaluated. This time delay would permit fuel flow before helium flow thus reducing the probability of freezing.

3.3.2 (continued)

Descent (continued)

Several configuration studies were initiated involving the helium pressure regulators, quad check valves and the addition of squib valves downstream of the quad check valves.

The supercritical versus ambient helium pressurization configuration decision still remains unresolved. The mission success estimates for the supercritical and ambient tankage subsystems are .999385 and .999393 respectively.

3.3.3 Reaction Control Subsystem

The reliability estimate of this subsystem has increased slightly (revised failure rates) during this report period. The major effort was directed towards the reliability evaluation of the RCS fuel and oxidizer tank bladder data supplied by Bell.

3.3.4 Navigation and Guidance - Stabilization and Control

Revised failure rates for the MIT equipment has reduced the reliability of this subsystem during this report period. Also, the reliability logic diagrams and equipment operating times have been updated.

3.3.5 Environmental Control

The mission success and crew safety estimates for this subsystem have decreased during this report period. These computations have been generated from the new math models and support data based upon the latest ECS configuration (LDW-330-21000).

Math models and mission success estimates have been generated for 4 ECS Battery-Heat Transport-Water Management Module configurations (Reference LED-550-62, dated 1 October 1965).

3.3.6 Instrumentation and Communications

The configurations of Instrumentation equipments such as the PCM, TE and C&WEA have reflected significant SWIP changes during the last quarter. Since these changes have not been fully confirmed by MSC, the total subsystem numerical reliability changes have not been incorporated in this report. The completion of the Measurement Change Request (MCR) interface meetings between MSC and GAEC have resulted in a temporary freeze of the LEM 10 measurements list. Initial instrumentation sensor reliability models together with groundrules and assumptions have been published in LED-550-70. It is anticipated that utilizing the revised LEM 10 measurements list and the sensor reliability models; system reliability estimates will be made during the next quarter for both sensors and signal conditions.

The reliability estimate for the Communications subsystem has remained constant during the last quarter. The evaluation and updating of the reliability model has continued and efforts to substantiate electromechanical and mechanical part failure rates have been carried out.

3.3.7 Explosive Devices

The mission success and crew safety estimates for this subsystem have increased from the previous report. This is due to a reduction of 4 squibs for descent deadfacing. The mission success model still considers the ascent-descent stage separation, landing gear actuation, ascent and descent propulsion pressurization and reaction control pressurization and mechanisms as serial assemblies. Only the ascent-descent separation and the ascent pressurization mechanisms are considered for crew safety.

TABLE 3.3.1

Mission Success Reliability Apportionments and Estimates

Subsystem	Apportionment	9th Quarter Report Estimate	10th Quarter*** Report Estimate	Remarks
Navigation & Guidance and Stabilization & Control	.990700	.988205	.984131	Latest MIT Failure Rates in 10th Report
Descent Propulsion	.999075	.998764	.998557	Latest STL Engine Failure Rates in 10th Report
Ascent Propulsion	.999961	.998300 **	.997954 **	10th Report based on revised check valve operating profile and latest Ascent Engine Math Models
Reaction Control	.999804	.919600	.919862	
Electrical Power	.998600	.963896	.965211	10th Report Estimate Based on a more detailed and comprehensive math model.
Environmental Control	.999446	.994760	.993755	10th Report Estimate Based on latest Level III schematics
Communications	.99991	.997680	.997680	
Instrumentation and Displays	.999500	.999378	.999378	Estimates does not include sensors, signal conditioners and Displays
Structures	.999950	.999978	.999978	
Explosive Devices	.999980	.999924	.999930	10th Report configuration has 4 less squibs for deadfacing system
Crew Provisions	.99999	*	*	* No estimate available
TOTAL	.987	.866	.856	

** Supercritical Helium Pressurization Subsystem

*** 10th Quarterly Report no longer considers pre-launch time (10 hours)

TABLE 3.3.2

Crew Safety Reliability Estimates

Subsystem	9th Quarterly Report Estimate	10th Quarterly * Report Estimate	Remarks
Navigation and Guidance and Stabilization and Control and Communications	.999651	.999602	Latest MIT Failure Rates in 10th Report
Descent Propulsion Ascent Propulsion	.999399	.999420	10th Report based on revised check valve operating profile and latest Ascent Engine math models
Reaction Control	.997807	.997807	
Electrical Power	.999993	.999959	10th Report Estimates Based on more detailed and comprehensive Crew Safety Math Models
Environmental Control	.999994	.999666	
Explosive Devices	.999954	.999960	10th Report configuration has 4 less squibs
Structures	.999999	.999999	
TOTAL	.99680	.99642	

* 10th Quarterly Report no longer considers pre-launch time (10 hours)

3.4 Reliability Modeling

3.4.1 Mission Success Models

Mission Success reliability models have been developed in detail in this quarter for the Electrical Power Subsystem, the Environmental Control Subsystem, the Explosive Devices Subsystem, and the Descent engine. Previously developed models have been reviewed and updated where required on the Navigation and Guidance, Stabilization and Control, Ascent Engine, Propulsion Pressurization and Feed, Communication, Instrumentation and Structures Subsystems. Studies are continuing on all subsystems in an effort to describe their models at lower assembly levels. The present models reflect subsystem configurations most indicative of current status as of 15 September 1965. The LEM vehicle level three diagrams were used as a basis for the models and the Design Reference Mission, dated 1 November 1964 was considered as a base profile for the description of mission phases in the modeling.

The present math models and their support data (failure rates and sources, operating profile and ground rules and assumptions) information for all the LEM subsystems were presented to NASA/MSC/GE Data Verification and Review Team on 31 August and 1 September 1965. It was agreed that the models and failure rates as presented will be the common "base line" for the present and future analyses. The basic models and support data will be modified whenever mission profile, equipment usage or equipment configurations are changed.

Reliability modeling and estimation techniques have been thoroughly described in previous quarterly reports. The format or procedure used in evaluating and modeling each subsystem consisted basically of three parts: (1) definition of Success Ground Rules, Assumptions, and Abort Criteria, (2) description of the Success Paths and Minimal Cuts and/or Reliability Block

3.4.1 Mission Success Models (continued)

Diagrams, and (3) use of Reliability Estimation Techniques such as Computer Programs. The level of detail described in the models has varied with the availability of design detail; i.e., from the level of parts such as valves in propulsion subsystems to the large assembly levels of the Landing Gear Assembly or Caution and Warning Equipment Assembly which still remain to be clearly defined.

The following LED's describe the reliability models and support data that have been developed for all the subsystems.

LED-550-57	Communication Subsystem
LED-550-65*	Guidance and Control Subsystems
LED-550-66	Reaction Control Subsystem
LED-550-67*	Explosive Devices Subsystem
LED-550-68	Environmental Control Subsystem
LED-550-69	Electrical Power Subsystem
LED-550-70	Instrumentation and Displays
LED-550-71	Ascent Propulsion Subsystem
LED-550-75	Descent Propulsion Subsystem

* Not released yet

3.4.2 Crew Safety Model

Previously developed crew safety models have been reviewed and updated when applicable on the other LEM Subsystems. The detailed LEM subsystem crew safety models were not integrated into an over-all LEM system crew safety model during the current reporting period. The Over-all LEM System Crew Safety Model will be generated during a future reporting period.

3.4.3 Computer Program

During this report period effort was directed towards modifying the Lower Bound Reliability Computer Program for a more efficient and versatile operation. The Lower Bound Reliability Computer Program as described in previous reports and other recently generated supporting programs have been used extensively in this reporting period. These programs have been used to generate and update configuration and sub-system reliability estimates utilized in trade-off

3.4.3 Computer Program (continued)

studies, mission success and crew safety estimates, and reliability apportionment.

3.5 Configuration Analysis and Reliability Trade-Off Studies

3.5.1 General

During this report period, eight (8) studies requiring systems level analysis, wholly or in part, were completed. They are listed below:

1. Early Pressurization of Ascent Propulsion Subsystem
2. Reliability Implications Due to Proposed Ascent Trajectory Changes (DRM II).
3. Degradation of S-Band Steerable Antenna Assembly Performance Due to Lunar Touchdown Environments.
4. Timing Electronic Assembly Weight-Reliability Trade-Off Study
5. Reliability Effects of Radiation Damage to LEM Transistors
6. Caution and Warning Electronics Assembly Effects on Abort Criteria
7. Reliability Evaluation of Proposed Descent Propulsion Subsystem Configuration Changes.
8. Radiation Effects from the RTG on Pyrotechnics

3.5.2 Early Pressurization of the Ascent Propulsion Subsystem (APS)

A study as reported in the previous quarterly was undertaken to determine whether there is a need from the viewpoint of crew safety to pressurize the APS prior to LEM-CSM separation. Additional findings to those mentioned in the last report now indicate that early pressurization would result in a substantial reduction in crew safety (.000165) and would subject the system to loss of pressurant and possible uncontrollable

3.5.2 Early Pressurization of the Ascent Propulsion Subsystem (APS) (continued)

combustion of propellants. This then subjects the crew to the same hazardous conditions as the original problem. Considerations and findings regarding this study are further detailed in LMO-550-682, dated 13 August 1965.

3.5.3 Reliability Implications Due to Proposed Ascent Trajectory Changes (DRM II)

The proposed guidelines for AMPTF DRM II Trajectory Computations were reviewed and analyzed to determine the possible affects of the change of LEM operating mission profile on mission success and crew safety. Based on the present (nominal DRM) math models the change in mission profile would result in a decrease in reliability (due strictly to the increase in mission time). However, a more accurate quantitative comparison can only be made after all possible subsystem reliability implications are investigated. For example, the Guidance and Control math model would be revised to show S-Band MSFN as a backup for PNGS and AGS, and also as a backup for CSM Optics and Rendezvous Radar. These new success paths would probably result in an increase in mission success and crew safety of .000015 for the DRM II estimate. However, a large increase in mission success would be realized if the capability of reliance on MSFN allows us to change the abort criteria. It is also felt that the DRM II mission of rendezvous within Line of Sight of earth offers many advantages that in the long run may improve reliability of successive flights. Preliminary evaluation of the possible reliability implications are further detailed in LMO-550-662, dated 21 June 1965.

3.5.4 Degradation of S-Band Steerable Antenna Assembly Performance Due to Lunar Touchdown Environments (continued)

An evaluation of the S-Band Steerable Assembly with respect to probability of failure due to lunar touchdown environments has resulted in the following observations.

3.5.4 Degradation of S-Band Steerable Antenna Assembly Performance Due to Lunar Touchdown Environments (continued)

1. Possible collection of lunar dust in gears and bearings causing loss of steerability is extremely improbable. Labyrinth shields, protecting the assemblies and making even the escape path of gaseous molecules difficult, preclude the possibility of foreign matter entering the housing.

2. It is anticipated that stresses set up on the dish by the RCS plumes, along with the vibrations transmitted through the LEM structure, are the most severe forces which will be encountered. The antenna assembly is being designed to withstand the specification limits.

3. Any short circuits in the steerable antenna assembly will not damage the power amplifiers. The power amplifiers are designed to withstand a short-circuited output for a period of 5 minutes, according to specification. Thus, it is very unlikely that minor disturbances in Standing Wave Ratio resulting from dust penetration will degrade communications.

3.5.5 Timing Equipment Weight-Reliability Trade-Off Study

Due to the elimination of the functional requirements for timing equipment operation during translunar flight, the total operating time requirement for the nominal LEM mission have been reduced by 70 hours or two-thirds of the total mission. In light of the operating time change, a detailed weight-reliability trade-off study has been carried out to ascertain the need for the extensive redundancies within the Timing Equipment. The results of this study indicates that an optimum balance between weight and reliability could be achieved with the deletion of the redundant Power Supply. LMO-550-690 presents the details of the analysis.

3.5.6 Nuclear Radiation Effects on Reliability

Nuclear radiation levels for LEM equipment and materials have been established and NASA/MSC has requested that these requirements be implemented in Exhibit B of Contract Technical Specification LSP-470-1A. Reliability and environments analysts have evaluated this criteria and found it incompatable with the present LEM system design. Grumman's position on the effects of the radiation hazard and the analytical procedure utilized in evaluating this hazard was documented and presented to MSC in LLR-560-117. A summary of this study can be described as follows:

During translunar flight solar flare protons may be encountered in such numbers that electronic equipment in the LEM could be significantly damaged. The astronauts, during this period in the mission, will (all) be in the CM and would not necessarily receive their allowable bioligical dose.

Probably the most radiation-sensitive devices which the LEM will carry will be silicon transistors. Some information is available on the effects of monoenergetic protons in damaging these devices. For this study, a critical type of silicon transistor was chosen for consideration. Using data on the relative effectiveness for producing damage by protons of various energies, NASA's model solar flare spectrum was transformed into a damage-equivalent, monoenergetic, integrated flux. Also available was a NASA curve with which the probability of encounter of a given equivalent integrated flux during the assumed mission time could be obtained. For particular shielding conditions the reliability of the device, so far as solar flare protons are concerned, was calculated.

A silicon transistor of alpha-cutoff frequency 0.6 Mc/s, shielded by a total of 130 mils of aluminum, was estimated to have a reliability of 0.99965. With 70 mils of additional shielding the reliability would rise to 0.99990. It is concluded that since the reliability of a transistor for all other types of failures is considerably higher than these numbers, the reliability of a

3.5.6 Nuclear Radiation Effects on Reliability (continued)

LEM electronic assembly containing such devices could be considerably compromised by the radiation sensitivity of its silicon transistors.

3.5.7 Caution and Warning Electronics Assembly (C&WEA) Effects on Abort Criteria

A detailed study of the effect of C&WEA failures on mission abort requirements has resulted in the elimination of Warning Logic and Precision Voltage Reference Supply redundancies. The rationale for these weight saving deletions can be described as follows: Estimates of the probability of failure for the C&WEA sub-assemblies do not reflect their contribution to the total LEM system mission abort probabilities. For example, a Power Supply failure would result in complete loss of the Caution and Warning function and would thus require mission abort or curtailment in most mission phases. However, channel failures in the Caution or Warning Logic do not necessarily constitute an abort requirement since there are alternate methods of obtaining vehicle status via operational displays and/or the telemetry-MSC analysis-MSFN-LEM voice link. Hence, failures in particular sub-assemblies do effect the over-all mission reliability while other sub-assembly failures have no significant effect.

3.5.8 Reliability Evaluation of Proposed Descent Propulsion Subsystem Changes

LMO-550-732, dated 11 October 1965, presents the results of an investigation of proposed configuration changes with regard to the effects on the reliability of the DPS. The configurations investigated were modifications of the existing configuration by:

a. Elimination of the secondary regulator and associated test point in each regulator leg.

b. Modification of the quad check valve (series check valves in parallel legs) by elimination of the parallel flow path and its associated test point.

3.5.8 Reliability Evaluation of Proposed Descent Propulsion Subsystem Changes (continued)

c. Addition of dual initiator isolation squib valves downstream (or upstream) of the check valves.

Reliability estimates and logic diagrams for the existing configuration and any combination of the proposed modifications are shown in this memo. It was recommended by reliability to incorporate the present quad check valve configuration with the elimination of secondary regulators plus the addition of isolation squib valves downstream of the quad check valves into the DPS. This configuration resulted in an increase in mission success reliability of ±.00025 with a weight penalty of only .8 lb.

3.5.9 Radiation Effects from the RTG on Pyrotechnics

LMO-550-673, dated 15 July 1965 presents information on the nuclear radiation effects from the Radio-Isotope Thermal-lectric Generator (RTG) upon pyrotechnic devices and other subsystems in LEM. Certain findings were brought to light by this study, they are:

1. RTG emphasizes the fact that no radiation testing is contemplated on LEM.

2. Radiation produced by solar flares is orders of magnitude higher than that produced by the RTG.

3.6 LEM Failure Mode and Effect Analysis

3.6.1 FMEA Status

During this report period two FMEA's were completed, one covering the Environmental Control Subsystem and the other the Descent Propulsion Subsystem (both ambient and supercritical helium). Both should be released early in the next report period. A few problem areas were brought to light as a result of performing these FMEA's. These problem areas are:

3.6.1 FMEA Status (continued)

1. Descent Propulsion System (DPS)

   a. The main problem affecting the supercritical helium storage section is leakage especially into the vacuum jacket. This failure would deteriorate the vacuum insulation material, raising the heat transfer rate of the supercritical helium and possibly creating a self-generating over pressure condition with eventual helium loss overboard or a tank bursting situation.

   b. A major problem in the supercritical Fuel/Helium exchanger is that helium will cause freezing of the fuel standing in the heat exchanger. The throttled fuel flow may create a drastic off nominal mixture ratio operation (moment unbalance) requiring mission abort with the ascent stage. Also ice particles flowing to the engine may cause catastrophic failure.

   c. Squib valves exhibit a failure possibility associated with the supercritical helium. One of the problems is temperature initiation of the explosives, the squibs are designed to fire at a low temperature of -260°F, while the supercritical helium circulation is at -460°F.

2. Environmental Control Subsystem

   There are certain deficiencies that exist in the present ECS configuration that should be investigated.

   a. The inability to isolate certain failures in the GOX system is of primary importance.

   b. The filters associated with the GOX portion can "fail closed". Presently there is no integral by-pass. This failure mode could cause mission abort or possibly loss of crew.

3.6.1 FMEA Status (continued)

2. Environmental Control Subsystem (continued)

   c. Rupture of tubing in the Secondary Water Management System would result in complete loss of the Ascent Water Supply. This potential single point failure could cause loss of crew.

   d. The location of the 503 pressure relief valve in the ascent stage is another potential external leak path should the 305 check valve fail open. Its function is to relieve overpressurization should the 3200 pressure regulator fail open. Since these failures would occur in the descent stage, the 503 pressure relief valve would effectively perform its intended function if it were located in the descent stage.

3.7 System Maintenance and Checkout

3.7.1 M3/M1B Ace Carry-On Removal Evaluation

Maintainability participated in the M3/M18 ACE Carry-on evaluations at NAA/S&ID during July and August 1965.

Pre-evaluations indicated the need for redesign in the following areas:

1. ACE carry-on "Birdcages" required slings and attach points for handling
2. ACE carry-on "birdcages" should be capable of being stepped on
3. It will probably be necessary to remove the VHF antennas during ACE carry-on transfer to prevent damage to the antennas
4. Light-weight, flexible cables should be used from the ACE carry-on to the vehicle
5. The ACE carry-on support structure required redesign to provide stability when lifting a "loaded" frame

3.7.1 M3/M1B ACE Carry-On Removal Evaluation (continued)

The evaluation also pointed out some general problems with the platform sets within the SLA.

1. Recommended deletion of the Xa6385 platform, and substitute a smaller portable platform

2. Recommended modification to platform support brackets to provide hand grips to assist mobility inside the SLA

3.7.2 Level III Drawing Review

During this quarter Level III wiring schematics were generated for nearly all subsystems of LTA-1. Maintainability reviewed all drawings for compatibility with maintenance concepts and requirements. Comments were provided during drawing review sessions, and changes occurring in the drawings as a result of subsystem interface problems were monitored to evaluate the impact upon maintainability characteristics. The Project Reviews for approval of the drawings were also supported by Maintainability attendance.

3.7.3 GSE Maintainability

During this reporting period several Maintainability design analyses have been performed using worksheets developed for this purpose. Design change recommendations have been issued to GSE Engineering as a result of these analyses and some modifications have been, or are being incorporated into the designs. A Maintainability analysis format was developed to enable the Maintainability Engineer to perform a thorough analysis of the MEE. It will assist in defining the problem areas by identifying the components that are responsible, and facilitate the resolution of these problems. The emphasis is being made on the Maintainability of the equipment at its location of operation and the remedial actions required during the prelaunch countdown. Recommendations for improvement will be documented and discussed with the cognizant GSE Engineer.

3.7.3 GSE Maintainability (continued)

Operational Readiness

The NAA Operational Readiness Evaluation Methodology Development Study (SID 65-885) was reviewed. It was mainly concerned with a computer program to evaluate the probability of launch success based on GSE restorability. The program requires extensive reliability and maintainability data and a complex computer operation.

The GAEC program plan is primarily concerned with the ability to restore the MEE to service in the least possible time and to recommend modes of redundancy to optimize launch readiness. The plan is being developed that will utilize the data concerning the equipment location, component replacement, restoration time, and operating conditions, to determine the most efficient level of readiness to meet a launch window.

3.8 Reliability Assessment

During this report period effort was directed towards review and commenting on the MSC reliability assessment plan (Quantitative Success Index). Systems Reliability is presently investigating the effort required to implement this plan.

3.9 LEM Reliability Computer Program

The planned effort to develop an integrated reliability computer program continued throughout this quarter. Attention was mainly centered on the failure data activity and on the test identification function. As a result of this effort, operational programs were completed for the following disciplines.

Failure Reporting
Failure Analysis
Corrective Action
Test Identification

3.9 LEM Reliability Computer Program (continued)

The characteristics of the failure data program were modified as stated in LLR-550-101, dated 11 October 1965. These changes were made to facilitate the data preparation and data processing aspects of the LEM Reliability Computer Program (LRCP) without compromising the basis design requirements. The transmittal form illustrated in LPR-550-9, dated 1 August 1965, still is employed to prepare data from field failure reports for the LRCP. Also, failure data submitted to the LEM central failure data files continues to be sent, on a weekly schedule, to the Manned Spacecraft Center. Magnetic tapes used to transport this data are furnished by MSC.

Recently, a compatibility check was made of the LRCP failure data and LEM failure information in the Apollo Failure Data Bank. The primary purpose of this check was to assess the adequacy and reliability of the failure data tape submittal method. The check did not reveal any major discrepancies. The inconsistencies which were uncovered, could be attributed to the development nature of the program. It is expected that future compatibility checks will be conducted in an automated manner.

At present, three outputs are available from the LRCP failure data program. These outputs, as shown in figures 1, 2, 3 are the Failure Surveillance Report, the Monthly Failure Report Summary, the Failure Recurrence Review. Data can be sorted and selected in a variety of combinations for these formats.

The test Identification Program (TID) was developed and completed along the lines described in LLR-550-89, dated 10 August 1965. The transmittal form (Eng. 375.2) employed to prepare data for the TID is shown in figure 4 and it is used to enter both parts and equipment test data to the program. Detailed procedures for the preparation of the TID transmittal sheet were issued in LPC-550-6. The intent of this final program configuration is to provide a source from which qualification status lists

3.9 LEM Reliability Computer Program (continued)

(QSL) for parts and equipments can be generated. This has been accomplished with the QSL format shown in figure 5. In anticipation of MSC requirements, QSL data were prepared on a magnetic tape which was forwarded to MSC with one copy of the printed QSL. As LLR-550-113, dated 18 November 1965 states, this is the first of scheduled bi-weekly submittals of qualification status information on magnetic tape. Grumman has suggested that a procedure similar to that used for failure data transmittal would be advisable for future QSL submittals.

Concurrent with the development of the TID program, work was terminated on the parts control section of the LRCP. It became obvious as the design of the TID input format was concluded, that the significant information expected from the parts program could be obtained from the TID data files. This decision also minimized the effort required of the LEM parts group to maintain the LRCP.

4.0 SUBSYSTEM ANALYSIS

4.1 Propulsion Subsystem

Summary of Effort for Period

a. Monitoring of engine subcontractors and pressurization and feed system vendors continued during the period. Reliability support was provided during negotiations with the Ascent and Descent engine subcontractors.

b. Configuration studies of proposed changes designed to eliminate the effect on crew safety of ascent engine solenoid valve single point leakage failures were completed, and a configuration was selected.(Refer to LMO-550-685, 19 August 1965 for details.)

c. A related study to determine whether valve redundancy to prevent leakage or a more accurate propellant leakage detection system would provide a more optimum crew safety reliability was completed in conjunction with the Systems Analysis Group. Conclusions of the study were that while a more accurate propellant leak detection system would be of value, crew safety reliability would be improved to a greater degree by providing valve redundancy.

d. Interface meetings were conducted with TRW (Descent Engine) Reliability personnel on June 17-18 (LMM-550-30) and July 12-14 (LMM-550-31). Failure rates for the Shut-off valve, flow control valve, piping and ducting and the injector were reviewed in detail and agreement was reached for failure rates to be used in future calculations. It was also agreed that TRW will re-calculate all reliability estimates using the Grumman K-factors and mission profile (LLR-170-1584).

4.1 Propulsion Subsystem (continued)

Summary of Effort for Period (continued)

e. Direction was received from MSC to implement the Propellant Quantity Gaging Section (PQGS) LSP-270-9, for descent propulsion. Reliability participated in concept studies (LMO-550-681, 12 August 1965) and in the proposal evaluations (LAV-550-1400, 26 August 1965). Selection of a vendor is imminent.

4.2 REACTION CONTROL SUBSYSTEM

- Reliability personnel attended the RCS common usage engine design review at TMC (Reference LMO-550-689)

- TMC program plan has been approved.

- Results from bladder development tests indicate that the use of undersized bladders solves the problem associated with refilling.

- During this period meetings were held with Giannini on the reliability status of the propellant quantity gaging program. A preliminary design review was also held at GAEC. The Giannini Program Plan was approved. Presently, a study is being made of the radiation effect of the cobalt sources of the PQGS.

- Recommended design changes in the PQGS include replacement of fastening screws for the PQGS sensor blankets with latches.

4.3 GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM

Subcontractor Status

Subsystem Summary

Inasmuch as the GN&C subsystem is composed of a number of Contract End Items, which are in various stages of development, the progress of the reliability effort for the past period will be delineated on a Contract End Item basis.

However, there has been some effort expended which affects the entire subsystem, and is summarized below.

- Reliability has continued the overall subsystem failure effect analysis which considers the functional interface between the individual black boxes and between the other subsystems. It is expected that this analysis will be completed during the next report period.
- Reliability has participated in the Certification Test Program review meetings held with NASA/MSC during the report period.

Summary of Effort for Past Period

a. Rendezvous Radar/Transponder and Landing Radar

- Reliability has reviewed all subcontractor documentation submitted during the period in order to assess and direct the vendor's compliance with the reliability requirements of the subject purchase order. Those documents in which specific reliability problems were evident and to which comments were directed to the subcontractor are as follows:

  Failure Effect Analysis - The Landing Radar FEA review indicated lack of sufficient details to be considered useful. The subcontractor has been notified; a resubmittal is expected during the next report period.

4.3 GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM (continued)

a. Rendezvous Radar/Transponder and Landing Radar (continued)

Maintainability Analysis - RCA presently is determining the replacement intervals for limited life items. GAEC Reliability is presently evaluating methods of cooling the RR and LR antenna during ground checkout.

Reliability Data Lists - Landing Radar RDL16, 19, 20, 21 and 22 were reviewed and disapproved because of the lack of NPPAR's, specific application information, or erroneous failure rates. The subcontractor has been directed to resubmit corrected RDL.

Equipment performance Specifications - The subcontractor was apprised of the inconsistancy between the indicated transponder useful life and the requirements as stated in the overall radar section performance specification.

Program Plan for the Transponder Wave Guide Assembly - discrepancies in the test logic and T/V test requirements were indicated to the subcontractor

Test Plans, Procedures and Reports - RCA was notified of the maximum and minimum operating and survival temperatures which they should be using as guidelines in the radar design.

Renegotiation Proposal - GAEC Reliability participated in the evaluation and task analysis of the radar reproposal. As a result of these renegotiations, specific classifications in the area of reliability documentation, part deviations, etc. were made to RCA.

4.3 GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM (continued)

a. Rendezvous Radar/Transponder and Landing Radar (continued)

Negotiations on the Radar program redefinition were conducted during the period and reliability after the review of the technical and cost aspects of said proposals participated in the negotiations. In particular areas, such as the detail and scope of certain analyses, parts programs, etc. specific clarification and direction to RCA was necessary.

During this period, RCA has continued subassembly and assembly test for the 1X and 2L preproduction models. In conjunction with this effort, GAEC reliability has reviewed and made comments to test plans, procedures and reports.

Reliability has generated Qualification Test Matrix charts incorporating the NASA recommended changes to the Qualification Test program.

b. Attitude Translational Control Assembly

A revised Failure Effect Analysis by RCA is presently being reviewed and incorporated into the overall GN&C analysis.

Two preproduction units are presently at GAEC undergoing modified acceptance tests. This effort is being monitored by GAEC Reliability and failures are being closely scrunitized to assure satisfactory remedial action is taken.

Thermodynamic analysis have shown the heat concentration in one area of the cold rail exceeds the 2.25 watts/linear inch specification requirements, which in turn would result in part surface temperatures in excess of 160°F. These calculations, however, did not consider the heat dispersion along the rails which

4.3 GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM (continued)

b. Attitude Translational Control Assembly (continued)

could possibly alleviate the condition. GAEC reliability shall evaluate the test data, which RCA will provide, to ascertain if in fact we do have parts which are thermally over-stressed and GAEC will recommend remedial action where necessary.

c. Descent Engine Control Assembly

GAEC has reviewed RCA's proposed method for removing incapsulated modules from the mother board, which entails the imbedding of a "hot wire" in the adhesive between the module and the board. The subcontractor has been directed to provide sufficient evidence that this method will not have any detrimental effect on the mechanical and thermal characteristics of the mounting.

The subcontractor has been directed to provide an updated Failure Effect Analysis because of technical changes since the original submittal. It is expected that said analysis will be provided and reviewed by GAEC Reliability during the next report period.

d. Rate Gyro Assembly

During the report period, GAEC Reliability participated in the Preproduction Design Review, at which time Reliability indicated that the subcontractor in order to meet the vibration requirements of the test program had failed to comply with other contractual requirements. The design was therefore considered to be unacceptable by Reliability. The subcontractor has been directed to provide additional analysis, the results of which will be reported in the next quarterly report.

4.3 GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM (continued)

d. Rate Gyro Assembly (continued)

Associated with this problem, GAEC Reliability is presently reevaluating the feasibility of the proposed reduced vibration test levels.

e. Abort Guidance Section

GAEC Reliability participated in a weight/power reduction meeting at UACSC in an effort to evaluate, where if possible, the weight of the Abort Sensor Assembly could be reduced without compromising the reliability of the assembly.

Reliability is in the process of reviewing the documentation associated with the Abort Sensor Assembly preproduction design review which is scheduled early in the next report period.

As a result of the review of subcontractor documentation, TRW/STL has been requested to investigate possible repackaging techniques so as to decrease the length of the thermal paths and thereby reduce the part surface temperatures.

f. Gimbal Drive Actuator

During the report period, the subcontractor has been notified of the delinquency of certain reliability documentation and as a result, all such documentation is expected to be submitted during the next report period.

As a result of a request of GAEC Reliability, the subcontractor has removed the calibrated stroke adjustment.

GAEC is presently investigating the feasibility and practicality of changing the GDA connector qualification test requirements to include the applicable thermal requirements of the GDA.

4.3 GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM (continued)

g. Attitude Controller Assembly

During the report period, GAEC Reliability participated in the Experimental Design Review Meeting at which time the design was frozen.

h. Program Reader Assembly

As a result of the susceptibility of the Tape Transport Assembly to vibration, which has necessitated vibration isolation which has resulted in thermal isolation, parts contained in the assembly will achieve surface temperatures in excess of 90°C. Because of the associated increase in failure rates of the discrete parts, Fairchild has been directed to take the necessary steps to reduce this thermal overstress condition.

i. Program Coupler Assembly

Inasmuch as GAEC has the responsibility for the PCA, GAEC Reliability has actively supported this in-house effort by providing the reliability documentation as required by the requirements of the subject purchase order.

GAEC Reliability has supported the feasibility testing of various PCA circuits which have resulted in the modification of the interface circuits between the LEM Guidance Computer and the PCA.

4.4 COMMUNICATION SUBSYSTEM

Subcontractor Status

Subsystem Summary

Summary of Effort for Past Period

During the report period extensive vendor liaison and coordination has continued by means of:

a. Review of subcontractor documentation - The specific subcontractor documentation which was reviewed and commented on included performance specifications, monthly progress reports, quarterly design reports, proposals, reliability data lists, etc. The comments of GAEC reliability were forwarded to the subcontractors and the necessary rectifications and clarifications are in the process of being implemented.

b. Participation in technical coordination meetings with the subcontractors and with GE/MSC personnel - meetings were held both at GAEC and at the subcontractors facilities in a continuing effort to improve the subsystem's reliability. Of particular importance, have been the meetings held at Raytheon between representatives of GAEC reliability, RCA and Raytheon. The purpose of the meetings have been to discuss the reliability and technical aspects of the Amplitron tube, which has presently exhibited severe development problems.

   Also during the report period the overall status of the Communication Subsystem reliability program was presented and discussed with GE/MSC personnel. Specific items that were presented included the subsystem reliability mathematical model and the estimated probabilities of success of the constituent units. As a result of these meetings, and as a normal function of the reliability effort, an update of this data is in process and will be available during the next report period.

4.4 COMMUNICATION SUBSYSTEM (continued)

Summary of Effort for Past Period (continued)

c. Participation in Design Reviews - The following design reviews were held during the report period at which action items were established, which are in the process of being answered.

- S-Band Steerable Antenna
- VHF Transceiver
- S-Band Power Amplifier

d. A reappraisal of the subsystem reliability estimates was continued during the report period in order to provide representative predictions for the communication subsystem.

e. Considerable effort was expended in providing maintainability direction to the subcontractor in the postulation and performance of an adequate maintainability philosophy.

f. The communication subsystem reliability model has been revised and updated. Sixteen model models have been completed in which the major capabilities of the subsystem have been delineated (e.g., uplink and downlink, S-Band voice and data transmission, VHF transmission, television capability, emergency voice and keying, etc.)

g. GAEC has requested from AVCO a complete stress analysis including a dynamic analysis to determine the stability of the erectable antenna during the opening operation. It is expected that such an analysis will be submitted during the next period.

h. Subcontractor submittals of worst case circuit analyses have been reviewed for the determination of adequate safety margins in the design, and for compatibility with submitted failure effect analyses and RDL's.

4.4 COMMUNICATION SUBSYSTEM (continued)

Summary of Effort for Past Period (continued)

i. Failure reports and the attendant failure analysis/corrective action are continuously being reviewed for the recognition of such things as the incipient failure modes and mechanisms of parts, the consequences on the subsystem performance and the adequacy of the subcontractor's analysis and corrective action.

4.5 ENVIRONMENTAL CONTROL SUBSYSTEM

Environmental Control Subsystem Summary

Summary of Effort for Period

a. The NASA/GE Data Verification and Survey Team was at GAEC on June 28 and September 2, 1965 and the ECS Math Model was reviewed on these occassions. General agreement was reached in all areas. As agreed at the September 2 meeting, the ECS math model has been updated (see LED-550-68) and the Failure Mode and Effect Analysis has been revised (see LED-550-37A).

b. During this period the ECS specification to Hamilton Standard was updated to include the following:

   i. The new performance requirements to reflect the all battery Power Generation Section

   ii. The updated reliability requirements including the new reliability test requirements as agreed to by NASA and GAEC (see LED-550-59 and LED-520-1D).

   Negotiations are currently underway with HSD on the above.

c. During this period a maintainability study was completed on the ECS to determine the adequacy of ECS checkout. The study resulted in the recommendation to checkout the coolant loop at approximately T-8 days in lieu of T-80 days (see LMO-550-674).

d. During this period GAEC has continued to monitor the status of the Brushless d.c. motors. At the request of GAEC reliability HSD prepared status report on all testing and failures of the three ECS brushless d.c. motors as of September 7, 1965.

Summary of Effort for Period (continued)

d. This information was given to NASA/MSC in response to a request during this time.

e. During this period the ECS configuration was changed to show the elimination of automatic switchover of glycol pumps (290 package) as recommended by reliability in LED-550-37.

f. During this period the Super Weight Improvement Program (SWIP) was initiated at which time reliability recommended (among other items) the elimination of GAMAH connections in the ECS. This increases reliability by eliminating leakage paths and decreases weight by going to brazed points. Action is pending on this item.

g. The following reliability meetings were held with HSD during this period:

   i. August 24 meeting at GAEC - to resolve requirements of new Sections D and E (reliability requirements) (see LVM-1150-0878).

   ii. September 16 meeting at GAEC on reliability aspects of HSD instrumentation (see LMM-550-35)

4.6 ELECTRICAL POWER SUBSYSTEM

Summary of Effort for Period

a. General Purpose Inverter (LSP-390-9)

The current electrical design has reached a stage where the vendor indicates that a weight vs performance trade-off will be submitted to GAEC.

Serial #6 was tested for RFI. As a result all leads on input and output filters were shortened to decrease RFI.

Tests have been run on the secondary simulator and data is now being evaluated. Design Feasibility Tests have been started. All preproduction parts have been procured. Application for production parts approval has been sent to GAEC.

For maintainability the control circuitry will be divided into four separate modules. LMO-550-715, dated 4 October 1965, outlines maintainability requirements.

b. Lighting Control Assembly (LSP-390-9)

Reeves has been selected as the vendor. A pre-contract meeting was held to review the specifications.

c. Batteries, Ascent and Descent (LSP-390-21, and 22)

The batteries are being designed and manufactured by Eagle Picher. At the present time, they are in the development phase. Design Feasibility Tests are being run.

Maintainability prepared Assembly Design Analyses on the Ascent and Descent Stage Electrical Control Assemblies, Ascent and Descent Stage Primary batteries.

LMA-390-02	D/S Battery
LMA-390-03	A/S Battery
LMA-390-04	A/S Electrical Control Assembly
LMA-390-05	D/S Electrical Control Assembly

4.6 ELECTRICAL POWER SUBSYSTEM (continued)

Summary of Effort for Period (continued)

c. (continued)

Maintainability has prepared and submitted LAV-550-1268 recommending a Descent Stage battery demonstration using the M-5 mockup. Prepared and submitted Maintainability Demonstration Data-Detailed Task Description dated 13 September 1965. These Data Sheets contain installation procedures, observations and measurements to be exercised and collected.

d. Maintainability prepared LMA-340-01 on the Electroluminescent lamps. Informal discussions with the subsystem engineers resolved the maintainability requirements attached to the above lamps. The present 2000 hour operating life of the lamps will remain as stated since locks are to be installed on the circuit breaker to prevent indiscriminate use.

Problem Areas

a. General Purpose Inverter

Operational characteristics are marginal in efficiency, inrush current, transient response, output ripple keeping within the temperature limits on the cold rail and keeping high power handling components below the 160°F maximum temperature limits are among the present development problems. To reduce resonant vibration points on chassis requires additional bracing.

b. Batteries, Ascent and Descent

The vendor is having difficulty fabricating the battery container in that there is difficulty in rolling and extruding magnesium.

4.6 ELECTRICAL POWER SUBSYSTEM (continued)

Problem Areas (continued)

b. (continued)

Reliability data is practically non-existant for Silver Zinc batteries for this capacity and application.

c. Batteries, Ascent and Descent

Finalization of the container fabrication technique.

Forty Descent Cells will be fabricated and tested in accordance with the Design Feasibility Test Program. Tests to reveal the transient voltage response will be performed on two ascent and two descent cells. Samples of gold, chrome, and nickel plated magnesium will under-go emmissivity tests.

4.7 STRUCTURES AND MECHANICAL DESIGN SUBSYSTEM SUMMARY

Summary of Effort for the Period

a. During this period an Allison Descent Stage Feasibility tank assembly test was successfully completed. Acceptance testing of the Aerojet General Feasibility tank was initiated.

b. Reliability participated in meetings to discuss stowing the pyro batteries in the ascent stage compared to leaving them on the descent stage. It was decided to leave the batteries in the descent stage because the change would have resulted in a considerable weight increase with little change to reliability.

c. During this period it was decided to use a pyro-technic guillotine in lieu of a proposed mechanical disconnect. Reliability recommended the use of the pyro separation method because of a single point failure in the mechanical system.

4.8 CREW PROVISIONS

No effort has been expended on this item during this report period.

4.9 INSTRUMENTATION SUBSYSTEM

Subsystem Summary

Sensors

The release of the purchase orders for the transducers was completed during the past quarter necessitating reliability support of the accompanying vendor negotiations. Subsequent submittal of the individual vendors Program Plans precipitated the review and approval cycle resulting in varying degrees of clarification and orientation of the vendors to insure compliance and understanding of the reliability requirements in their purchase orders.

Major Equipment (PCM/TEA, SCEA, C&WEA, DSEA, WQMD)

In addition to the continuing effort of vendor monitoring, documentation review and vendor negotiations the following significant efforts have been accomplished during the past quarter.

a. Completed efforts to generate an LED that presents the Instrumentation Reliability Block Diagrams and Information Flow Diagrams for the RCS, ECS and Propulsion Subsystems.

b. Completed a study to determine the feasibility of eliminating redundancy in the Timing Equipment assembly of the PCM/TEA: Reference: LAV-550-690.

c. Participated in a study which included evaluation of a vendor proposal to substantiate redesign and repackage of the PCM/TEA to facilitate a size and weight reduction.

d. Supplied the effort required to evaluate the recommended changes to the Instrumentation Qualification Program necessitated by the Certification Test Program review.

4.9 INSTRUMENTATION SUBSYSTEM (continued)

Major Equipment (PCM/TEA, SCEA, C&WEA, DSEA, WQMD) (continued)

e. Effort is continuing to complete the N&G Instrumentation Block Diagrams.

f. Meetings were held with Hamilton Standard to bring about a common agreement in the approach for analysis of the ECS Instrumentation.

g. Attended the Conceptual Design Review for the DSEA at Leach Corp.

h. Continued evaluating the results of the PCM/TEA Foam Preload Reduction Investigation that was instituted as a result of the last design review.

4.10 DISPLAYS AND CONTROLS SUBSYSTEM

Subcontractor Status

Subsystem Summary

During the report period, in addition to the subcontractor monitoring effort, some of the overall subsystem reliability tasks that have been initiated are as follows:

. a failure effect analysis of all monitored parameters has been initiated. It is anticipated that such an analysis will determine the criticality of each parameter and the justification for the monitoring of same.

. the reliability block diagrams for the measurements associated with the Propulsion, RCS and ECS subsystems were completed. The block diagrams for the GN&C subsystem are being developed and should be completed during the next report period.

. an analysis has been initiated assuming a maintenance philosophy of replacement of the entire panel on which the malfunctioned device is installed. Studies are also continuing to determine the feasibility of replacing limited life items, such as EL numerics, on the panel.

. In general, all of the units are in the design feasibility test phase and at present there is no indication of any significant problems

The progress of the subcontractor reliability effort and the monitoring of same of GAEC reliability is delineated below on a contract end item basis.

Summary of Effort for Post Period

a. Helium Teperature and Pressure Indicator

Kearfott has submitted a reliability estimate for the indicator during the period and is expected to submit a detailed FEA and reliability block diagram during the next period.

4.10 DISPLAYS AND CONTROLS SUBSYSTEM (continued)

Summary of Effort for Post Period (continued)

b. RCS Propellant Quantity Indicator - It has been indicated to Kearfott that the initial reliability estimate and block diagram are unacceptable to GAEC. The subcontractor has been directed to comply with the GAEC derating policy and to utilize the LEM failure rates where applicable.

c. Flag Indicator - As a result of configuration analyses performed, it was concluded that the "Leaf Spring Positioning Concept" would be more suitable than the "servometric concept".

d. Thrust to Weight Ratio Indicator - Bendix has been directed to submit a revised reliability estimate, block diagram, and the specifics on the configuration analysis of the available dumping methods.

e. Mission Elapsed Timer - As a result of the preliminary design review, Bulova has been directed to resubmit their reliability block diagram, FEA, FMPA, RDL, circuit analysis and a configuration analysis of the mechanical section of the device.

f. Range/Range Rate Indicator - Bendix has been apprised of the delinquency of specific reliability documentation. It is expected that full compliance of the documentation requirements will be accomplished during the next report period.

g. Digital Event Timer - As a result of the conceptual design review, Sylvania has been directed to submit all circuit schematics and RDL and to utilize the GAEC failure rates when applicable.

h. D'Arsonval and Cross-Pointer Meters - Honeywell has been directed to improve the submittal of their failure reports, utilize the GAEC failure rates where applicable and to resubmit a reliability estimate to reflect the latest design concepts.

4.10 DISPLAYS AND CONTROLS SUBSYSTEM (continued)

Summary of Effort for Post Period (continued)

i. Attitude Indicator & Gimbal Angle Sequence Transformation Assembly - In general Lear Siegler's performance has been considered adequate during the report period. One particular area which Lear Siegler is investigating at present is a microcircuit contamination problem. Corrective action has been initiated and tests are in progress to validate the remedial action.

j. ΔV Indicator - Sylvania has been directed to use GAEC failure rates when applicable in their reliability estimates.

4.11 GROUND SUPPORT EQUIPMENT (GSE)

General

Summary of Effort for the Period

The reliability effort on LEM GSE during the past reporting period has been concentrated in the following areas:

a. Update of mission-essential (MEE) and hazardous (HAZ) equipment listings (Reference a).

b. Review of vendor proposals, negotiations with vendors, and surveillance of vendors under contract including documentation review and design reviews.

c. Analysis of GSE failures at MSC/WSTF and Bethpage.

d. Review of mechanical parts/components documentation

e. Completion of 90% of FMEA's for MSC/WSTF GSE used to support PD-1

f. Rewrite of LVR "boilerplate" for GSE (Reference b)

g. Presentation to NASA at Apollo Checkout Panel #19 on backup cooling requirements for LEM after closeout (Reference c)

h. Active participation in GSE Status, Concept, and Requirements Review meetings

i. Reliability analysis on in-house GSE designs including design reviews (Reference d)

j. Publish procedure on GSE FMEA's (Reference f)

k. Establish reliability/maintainability input for GSE Top Spec (LSP-400-10)

l. Submission to MSC/ASPO of MEE List (Reference g) resulting in acceptance of same.

4.11 GROUND SUPPORT EQUIPMENT (GSE) (continued)

Projected Effort for Next Period

The anticipated effort for the next quarter shall include the following:

a. Complete reliability effort (FMEA) on GSE used to support PD-1, PA-1 and PD-2; start effort on HSC-1 and LTA-8 GSE.

b. Complete FMEA on Altitude Simulation Facility as directed by HA-3 DEI Chit #37.

c. Update reliability study on Supercritical He (SHe) as requested by NASA at design freeze (Reference h).

References

a.	LAV-550-1312 LAV-550-1350 LAV-550-1392	Changes to MEE and HAZ GSE Lists
b.	LED-550-79	LVR "Boilerplate" for LEM GSE
c.	LMO-550-684	Response to Checkout Panel #18, Action Item 18.1.56
d.	LAV-550-1356	Bidirectional P Transducer
e.	LMO-550-688	Response to Request for Power Failure Analysis for WSTF GSE Controllers
f.	LRP-550-1	LEM Reliability Procedure, LEM FMEA
g.	LED-550-48A	Prelaunch MEE Listing
h.	LMO-550-614	Preliminary Reliability Study of SHe Conditioning and Transfer Assembly, 430-64200

5.0 DOCUMENTATION RELEASED DURING THE REPORT PERIOD

5.1 MEMORANDUMS

Number	Date	Author	Title
LMO-550-659	6-15-65	G. Unruh	LEM Reliability Attitude Controller - Estimate of Improvement in Reliability due to Configuration Changes
LMO-550-660	6-15-65	G. Unruh D. Livaccari	LEM Reliability Attitude Controller - Configuration Analysis
LMO-550-661	6-18-65	G. Wiesinger	LEM Descent Stage Maintainability Demonstration
LMO-550-662	6-21-65	S. Weisberg M. Sabia	CONFIDENTIAL Reliability Implications of Data Proposed Ascent Trajectory Changes
LMO-550-663	6-25-65	D. Livaccari	Trip to Fairchild to Review PRA STM Design
LMO-550-452A	6-17-65	P. Marques	Outline of the In-house Reliability Program for GSE
LMO-550-664	6-28-65	G. Wiesinger	Apollo Program Reliability Briefing - Film Presentation of the NAA PSAC Discussions
LMO-550-665	10-29-65	H. Bluethenthal J. Kalpaxis	Tripped Circuit Breaker Alarm
LMO-550-666	6-30-65	D. Broggini J. Weipert	Reliability of LEM Pyrotechnic System
LMO-550-667	7-2-65	S. Perlmutter	Report of Meeting Held at Curtis Instruments, Incorporated, on 1 July 1965

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-668	7-2-65	G. Wiesinger	PROPRIETARY
LMO-550-669	7-2-65	A. Coretti D. Lappin	Minutes of 25 June Meeting 10-9 Toir Vacuum Tests of the Communication S-Band Steerable and Erectable Antennas
LMO-550-670	7-7-65	D. Lappin	Comments to Failure Mode Prediction Analysis for the RR Antenna and Electronics Assembly, Type II Document
LMO-550-671	7-13-65	J. Mule'	Submittal of Meeting Minutes
LMO-550-672	7-14-65	J. Gerardi	PROPRIETARY
LMO-550-673	7-15-65	G. Codina	Trip Report on Trips to Sandia, MSC, and SOS on Radiation Effects from the RTG on Pyrotechnics
LMO-550-674	7-27-65	J. Gruber P. Marques	Launch Readiness of the ECS Coolant Recirculation Assembly
LMO-550-675	7-29-65	J. Schmidt	Reliability Comments on EPS Deadface Relay Requirements
LMO-550-676	8-3-65	H. Gottschalk	Comments on TMC Support Manual Outline for the RCS Cluster Assemblies (Revised 15 June 1965)
LMO-550-677	8-5-65	J. Negrepont	Interstage Structural Fittings and Explosive Bolts
LMO-550-678	8-5-65	K. Moran W. Kircher	Reliability Comments on "LEM Alone" GSE Min/Max Stock

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-679	8-10-65	J. Kalpaxis H. Bluethenthal	SCEA Power Distribution Study
LMO-550-680	8-10-65	E. Bender	Reliability Evaluation of the Electrical Aspects of the RCS Propellant Solenoid Valve
LMO-550-681	8-12-65	D. Livaccari	Descent Engine Propellant Quantity Gauging Section Reliability Aspects
LMO-550-682	8-13-65	M. Sabia J. Leoniak	Crew Safety Reliability Considerations Relating to Pressurization of the Ascent Propulsion System During Pre-Separation Checkout
LMO-550-683	8-4-65	P. Marques D. Seidenspinner	PROPRIETARY
LMO-550-684	8-18-65	K. Moran E. Leonard	Response to Checkout Panel #18 Action Item #1 18.1.56
LMO-550-685	8-19-65	G. Gibbons	Estimated Reliability of Proposed Solenoid Valve Configurations for the LEM Ascent Engine
LMO-550-686	8-19-65	S. Malow	Utilization of Aluminum Wire on LEM
LMO-550-687	8-23-65	L. Petersen R. Esposito	Purchase Order 2-24487-C (C&WEA) Request for Deviation to Specifications

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-688	8-24-65	A. Doyle	Request for Power Failure Analysis for WSTF GSE Controllers
LMO-550-689	8-26-65	H. Arnzen	Trip Report - SM/RCS Engine Final Design Review at Marquardt Corp., Van Nuys, California
LMO-550-690	8-30-65	R. Lazarto J. Purcell	TEA Weight Reliability Study
LMO-550-691	9-1-65	J. Purcell	Reliability of Ground Plane, Dipole and Exterior Structure of the S-Band Steerable Antenna Assembly
LMO-550-692	9-1-65	M. Moroney	Reliability Qual Status List Formats
LMO-550-693	9-3-65	G. Wiesinger	Action Item 14 from 8-18-65 Line Item Review Meeting
LMO-550-694			CANCELLED
LMO-550-695	9-9-65	J. Wittenberg	Reliability Control's Comments on Ai-Research's Detail Acceptance Test Plan for the Supercritical Helium Tank Assembly, DATP-900144
LMO-550-696			CANCELLED
LMO-550-697	9-14-65	S. Perlmutter J. Lewandowski	Report of Meeting held at Curtis Instruments Inc. on 9 Sept. 1965

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-698	9-16-65	J. Wittenberg	Comments on Aerojet General DVT General Procedures No. 1-4081-01-52-6.0
LMO-550-699	9-17-65	J. Wittenberg	Request for the incorporation of an endurance test procedure to the Waste Management Section Specification, LSP-340-201A
LMO-550-700	9-20-65	A. Lih	GAEC - AiResearch Meeting Sept. 8-10 1965, LEM Gimbal Drive Actuator P.O. 2-24478
LMO-550-701			CANCELLED
LMO-550-702	9-21-64	A. Coretti	GAEC Response to Action Item 1.3.1.1 - 11
LMO-550-703	9-21-65	T. Plotkin	Trip to Deutsch Connector Company (Vendor) Banning, California and United Aerotest Lab (Vendor's Subcontractor) Monterey Park, California
LMO-550-704			CANCELLED
LMO-550-705	9-22-65	G. Wiesinger	PROPRIETARY
LMO-550-706	9-28-65	F. Howard	Monitoring of ASA Continuous Thermal Environment
LMO-550-707			CANCELLED
LMO-550-708			CANCELLED
LMO-550-709	9-29-65	G. Wiesinger	Non-Operating Part Temperatures

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-710	9-29-65	A. Coretti	PROPRIETARY
LMO-550-711	9-30-65	J. Arleth M. Klugman	Metallic Web Mounting of Electronic Parts
LMO-550-712	9-30-65	G. Wiesinger W. Doyle	Design Philosophy, Installation and Removal of Descent Engine in the Mated Configuration
LMO-550-713	10-4-65	R. Cappiello	Failure Rates Used for LEM Reliability Estimates
LMO-550-714	11-12-65	W. Doyle	Pressure Testing A&D Pressurization Section Explosive Valves
LMO-550-715	10-5-65	J. Negrepont	Maintainability Requirements, G.P. Inverter
LMO-550-716	9-29-65	G. Wiesinger	Recommended Changes to the C&D Equipment Qualification Test Program
LMO-550-717	10-5-65	G. Wiesinger	Recommended Changes to the Instrumentation Equipment Quali-fication Test Pro-gram
LMO-550-718	10-5-65	G. Wiesinger	Recommended Changes to the RCS Equipment Qualification Test Program
LMO-550-719	10-5-65	G. Wiesinger	Recommended Changes to the ECS Equipment Qualification Test Program

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-720	10-5-65	G. Wiesinger	Recommended Changes to the ECS Equipment Qualification Test Program
LMO-550-721	10-5-65	G. Wiesinger	Recommended Changes to the Propulsion Equipment Qualification Test Program
LMO-550-722	10-5-65	G. Wiesinger	Recommended Changes to the Radar Equipment Qualification Test Program
LMO-550-723	10-5-65	G. Wiesinger	Recommended Changes to the Propellant Tank and Cabin Window Qualification Test Program
LMO-550-724	10-5-65	G. Wiesinger	Recommended Changes to the Crew Provisions Equipment Qualification Test Program
LMO-550-725	10-5-65	G. Wiesinger	Recommended Changes to the EPS Equipment Qualification Test Program
LMO-550-726	10-5-65	G. Wiesinger	Recommended Changes to the Communications Equipment Qualification Test Program
LMO-550-727	10-5-65	G. Wiesinger	Recommended Changes to the S&C Equipment Qualification Test Program
LMO-550-728	10-8-65	G. Wiesinger	PROPRIETARY

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-729	10-8-65	J. Wittenberg	Comments on Ai-Research's Detail Verification Test Plan for the Supercritical Helium Tank Assembly No. DVTP-900144, dated 5 September 1965
LMO-550-730	10-11-65	E. Hornbuckle M. Moroney	Trip to Peconic Facility
LMO-550-731	10-11-65	E. Hornbuckle	Working Group Meeting No. 2 for LEM Equipment Flow in GAEC
LMO-550-732	10-11-65	G. Gibbons M. Sabia	Reliability Evaluation of Proposed Descent Propulsion Subsystem Configuration Changes
LMO-550-733	10-15-65	G. Wiesinger	CDR Inputs from Reliability
LMO-550-734	10-19-65	G. Wiesinger	PROPRIETARY
LMO-550-735	10-20-65	T. DeMund J. Negrepont	Battery Installation, LEM Descent Stage Maintainability Demonstration Requirements
LMO-550-736	10-20-65	L. Nardo	Review of MIT Drawing (1006361)
LMO-550-737	10-21-65	T. Plotkin	Trip to United Aerotest Labs, Monterey Park, California to discuss Implement and Observe Qualification Vibration Tests on LEM Connectors
LMO-550-738	10-21-65	S. Malow J. Schmidt	PROPRIETARY

5.1 MEMORANDUMS (continued)

Number	Date	Author	Title
LMO-550-739	10-25-65	D. Broggini	Configuration Analysis Interruption for ED Separator System, LEM's 1, 2, 3, and LEM's 4-11
LMO-550-740	9-21-65	G. Wiesinger	PROPRIETARY
LMO-550-741	10-25-65	D. Livaccari	PROPRIETARY
LMO-550-742	10-26-65	S. Malow	Data on Silver Zinc Batteries obtained from Reliability Meeting with Aerospace Corporation, El Segundo, California
LMO-550-743	10-26-65	G. Gibbons	Ascent Propulsion Subsystem Isolation Valve Configuration
LMO-550-744	10-26-65	S. Malow	Tabulation of Reported Silver Zinc Batteries Failures on the Mercury Program
LMO-550-745	10-27-65	G. Wiesinger	PROPRIETARY
LMO-550-746	10-27-65	D. Broggini	Initiator "O" Ring
LMO-550-747	10-29-65	H. Berman	Summary of RCS Failure Modes and Analysis

5.2 ENGINEERING DOCUMENTS

Number	Date	Author	Title
LED-550-58	6-18-65	F. Doyle	Failure Rate Data LEM System
LED-550-59	7-15-65	G.Wiesinger	Boiler Plate for P.O. Sections D and E Minor Sub-contractors
LED-550-60	4-26-65	S. Axel	Derating Policy for LEM
LED-550-48A	5-8-65	K. Moran	Prelaunch Mission Essential GSE, Listing of
LED-550-50A	5-8-65	K. Moran	Hazardous & Potentially Hazardous LEM GSE/STE, Listing of
LED-550-52A	5-8-65	K. Moran	Flight Mission Essential GSE, Listing of
LED-550-61	7-15-65	G.Wiesinger	Boiler Plate for P.O. Sections D & E Major Subcontractors
LED-550-62	7-20-65	W. Geier/ B. Byas	Estimated Reliability of Mattery-Heat Transport-Water Module Configurations for LEM ECS
LED-550-63	3-24-65	S. Axel	GAEC Part Qualification Proposal
LED-550-64	8-12-65	G.Wiesinger	GAEC LEM Subcontractor Reliability Task Description
LED-550-65	8-1965	A.Dantowitz	G&C Subsystem Math Model & Support Data
LED-550-66	9-23-65	M. Sabia	RCS Math Model

5.2 ENGINEERING DOCUMENTS (continued)

Number	Date	Author	Title
LED-550-67	9-1965	J. Schmidt	Explosive Devices Subsystem Math Model and Support Data
LED-550-68	9-15-65	B. Byas	Environmental Control Subsystem Math Model and Support Data
LED-550-69	9-15-65	B.Sullivan	Electrical Power Subsystem Math Model and Support Data
LED-550-70	10-26-65	J. Purcell	Instrumentation Subsystem Math Model and Support Data
LED-550-71	9-15-65	M. Sabia	Ascent Propulsion Subsystem Math Model and Support Data
LED-550-72	8-31-65	N.Rosenblum	Failure Mode and Effect Analysis-Propulsion Subsystem Checkout Station
LED-550-73	8-23-65	L. Slater	Failure Mode and Effect Analysis Test Conductor Console
LED-550-74	8-5-65	N.Rosenblum	Failure Mode and Effect Analysis Station Control RCS Stand LDW-410-62920-1
LED-550-75	9-15-65	M. Sabia	LEM Reliability Math Models and Support Data Descent Proposal Subsystem
LED-550-76	9-21-65	R. Lazarto	Reliability and Information Flow Block Diagrams for ECS-RCS & Propulsion Instrumentation
LED-550-77	9-23-65	S. Brown	Failure Mode and Effect Analysis Simulator, Ascent Engine 430-6090-69

5.2 ENGINEERING DOCUMENTS (continued)

Number	Date	Author	Title
LED-550-78	9-24-65	M. Sabia/ J. Leoniah	Failure Mode and Effect Analysis of the Descent Propulsion Subsystem
LED-550-79	9-24-65	M.Antonucci	LEM Reliability Boiler Plate Requirements For GSE/STE LVR Documents Sections D and E
LED-550-80	10-11-65	S. Berg/ G. Codina	Functional Failure Mode and Effect Analysis of the Explosive Devices Subsystem
LED-550-81	10-15-65	G.Wiesinger	Line Item 023 LEM Reliability Task Description and Rationale October 1965
LED-550-14A	10-15-65	H. Arnzen/ H. Berman	RCS Failure Mode and Effect Analysis